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Transportation Engineering

Presented by Robert Campbell
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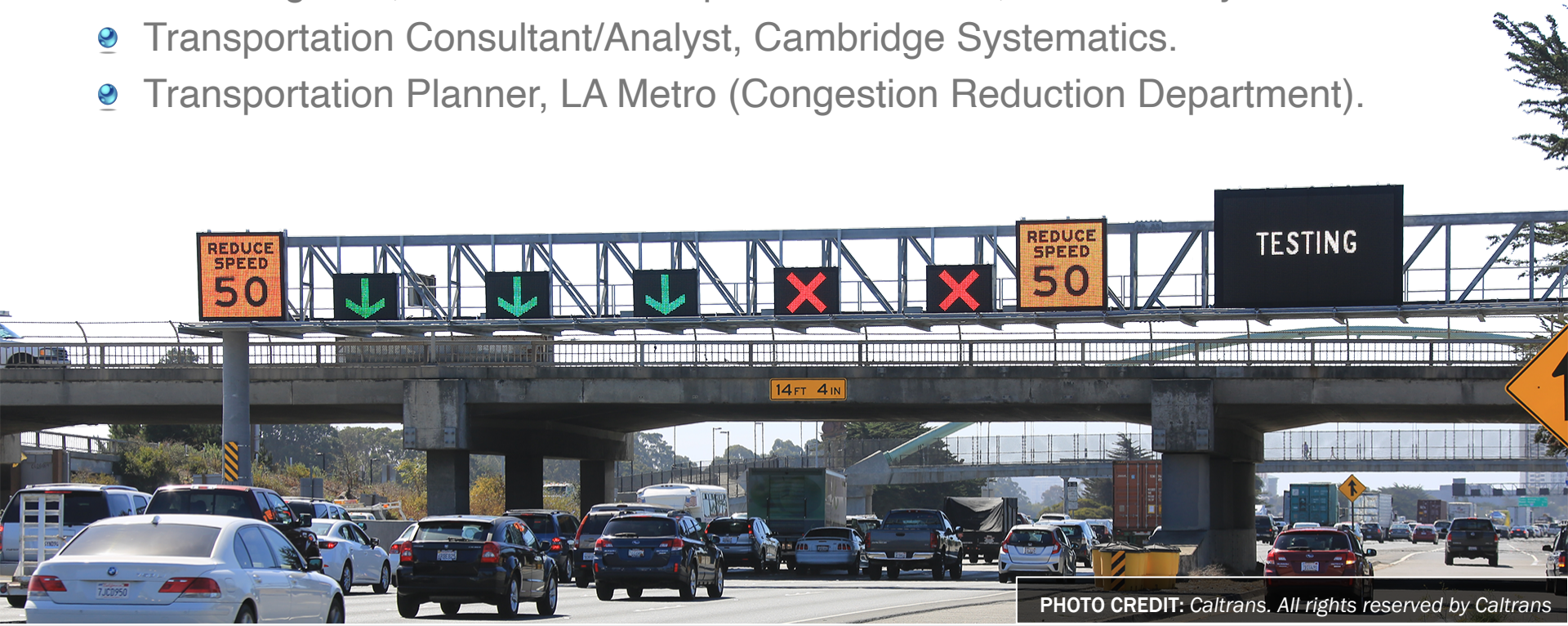
About your Presenter

- B.S. in Civil Engineering, UCLA
- M.S. & Ph.D. in Civil & Environmental Engr. (Transportation), UC Berkeley.
- R&D Engineer, Institute of Transportation Studies, UC Berkeley.
- Transportation Consultant/Analyst, Cambridge Systematics.
- Transportation Planner, LA Metro (Congestion Reduction Department).



The Transportation Profession

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Major Focus Areas

ROADS AND HIGHWAYS

AIR TRANSPORTATION

PUBLIC TRANSIT BUSES AND RAIL

FREIGHT AND GOODS MOVEMENT

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Private and Public Sector

Public Sector	Private Sector
Work on larger projects, start to finish	Work on a greater diversity of projects
Respond to the needs of the public	Respond to the needs of public agencies
Ask guiding questions, define objectives	Provide solutions, fulfill objectives

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Active Research Areas

Roles and Responsibilities

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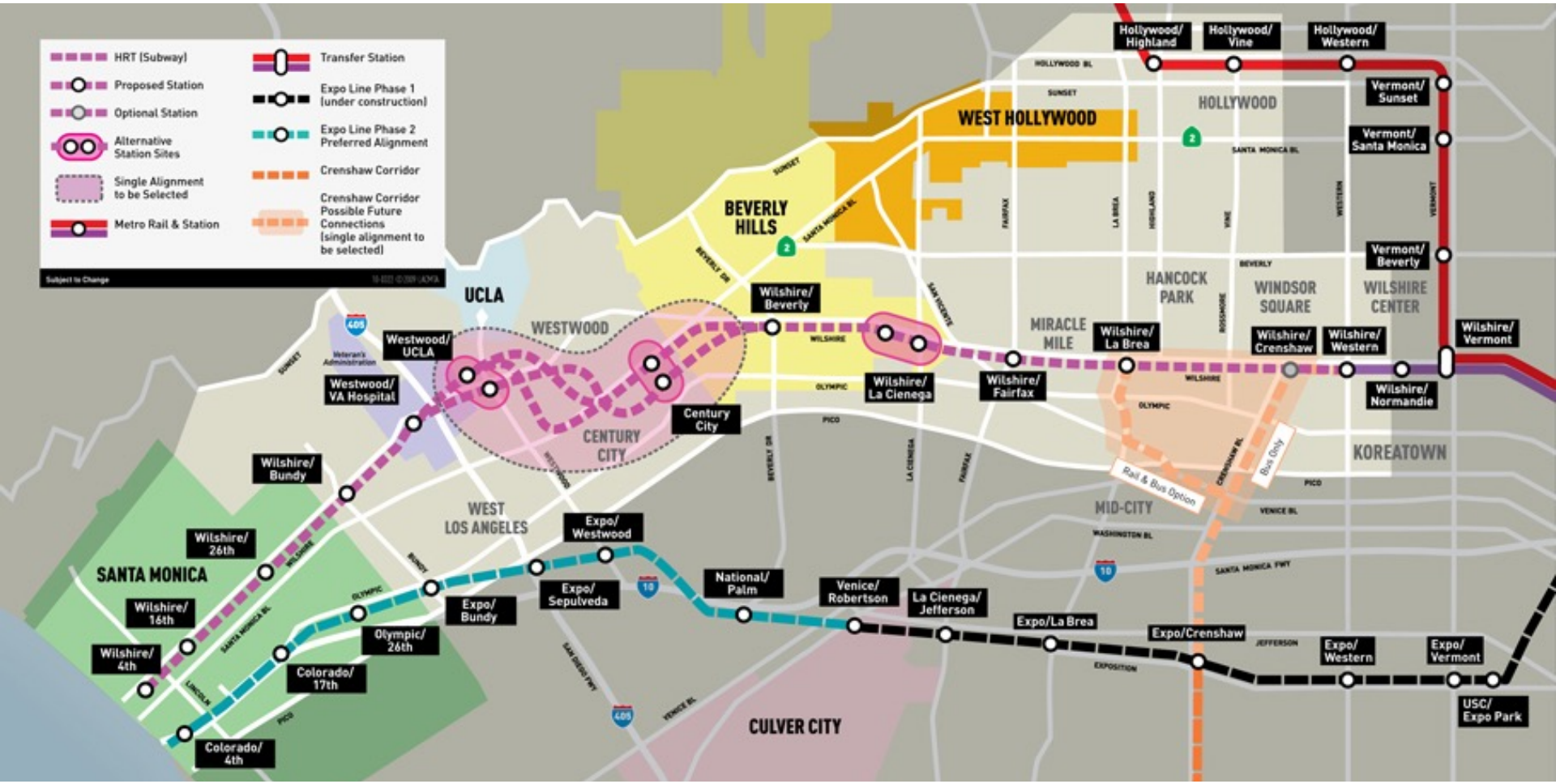
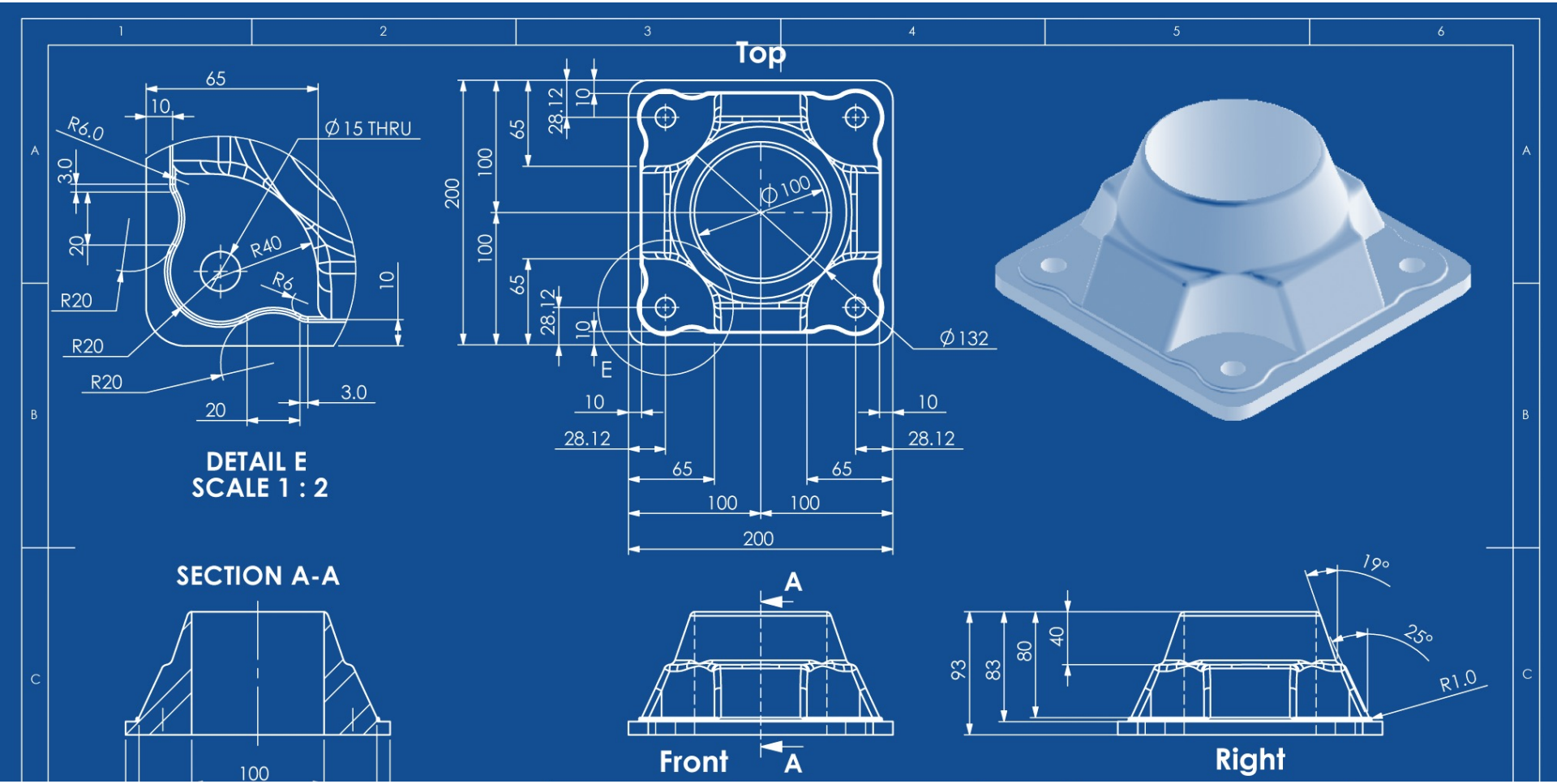
Planning


HRT (Subway)
Proposed Station
Optional Station
Alternative Station Sites
Single Alignment to be Selected
Metro Rail & Station
Transfer Station
Expo Line Phase 1 (under construction)
Expo Line Phase 2 Preferred Alignment
Crenshaw Corridor
Crenshaw Corridor Possible Future Connections (single alignment to be selected)
Subject to Change
Hollywood/ Highland
Hollywood/ Vine
Hollywood/ Western
Vermont/ Sunset
Vermont/ Santa Monica
Vermont/ Beverly
Wilshire/ Vermont
Wilshire/ Western
Wilshire/ Crenshaw
Wilshire/ La Brea
Wilshire/ Fairfax
Wilshire/ La Cienega
Wilshire/ Beverly
Wilshire/ Normandie
Westwood/ UCLA
Westwood/ VA Hospital
Century City
Wilshire/ Bundy
Wilshire/ 26th
Wilshire/ 16th
Wilshire/ 4th
Colorado/ 4th
Colorado/ 17th
Olympic/ 26th
Expo/ Bundy
Expo/ Sepulveda
Expo/ Westwood
National/ Palm
Venice/ Robertson
La Cienega/ Jefferson
Expo/La Brea
Expo/Crenshaw
Expo/ Western
Expo/ Vermont
USC/ Expo Park
Rail & Bus Option
Bus Only
WEST HOLLYWOOD
HOLLYWOOD
BEVERLY HILLS
UCLA
WESTWOOD
CENTURY CITY
WEST LOS ANGELES
SANTA MONICA
MIRACLE MILE
HANCOCK PARK
WINDSOR SQUARE
WILSHIRE CENTER
KOREATOWN
MID-CITY
CULVER CITY

Design


Top
DETAIL E
SCALE 1 : 2
SECTION A-A
Front
Right
A
A
65
10
R6.0
Ø15 THRU
3.0
20
R40
R6
R20
R20
R20
10
3.0
20
200
100
100
65
28.12
10
Ø100
Ø132
E
10
28.12
65
100
200
10
28.12
65
100
19°
25°
R1.0
93
83
80
40
100

Construction

Operations

Maintenance

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Addressing Congestion

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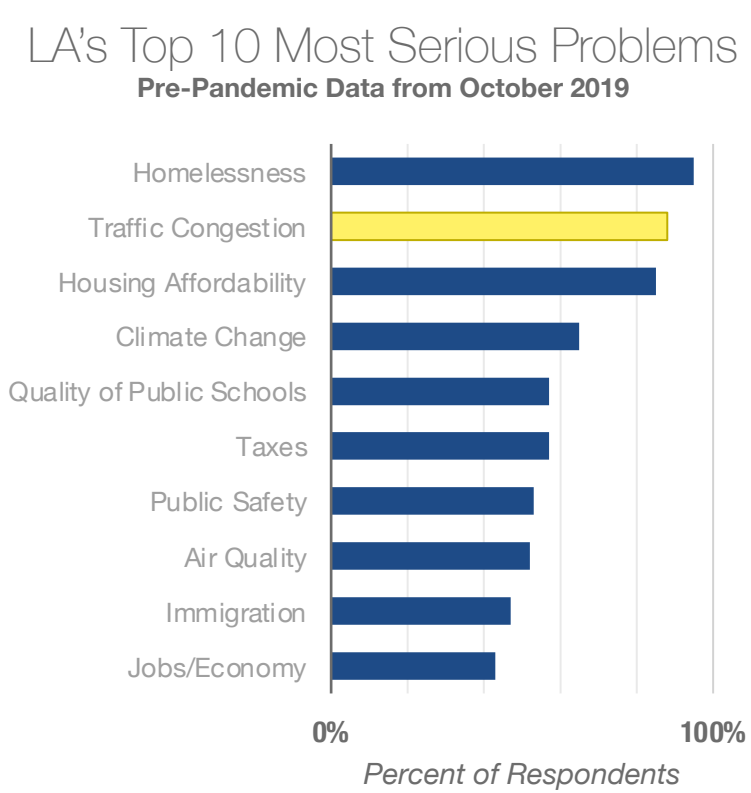
A Widespread Concern



DATA SOURCE: Benjamin Oreskes, Doug Smith, David Lauter. "95% of voters say homelessness is L.A.'s biggest problem, Times poll finds." *Los Angeles Times,* November 14, 2019.

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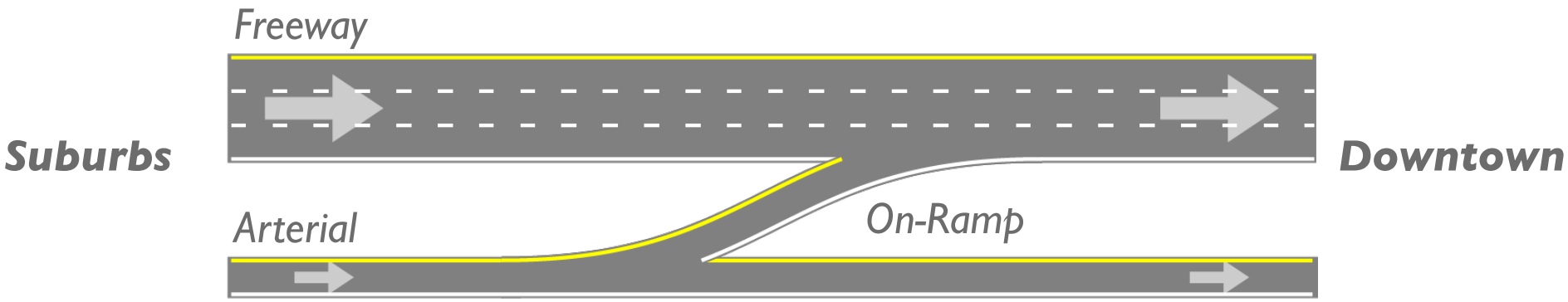
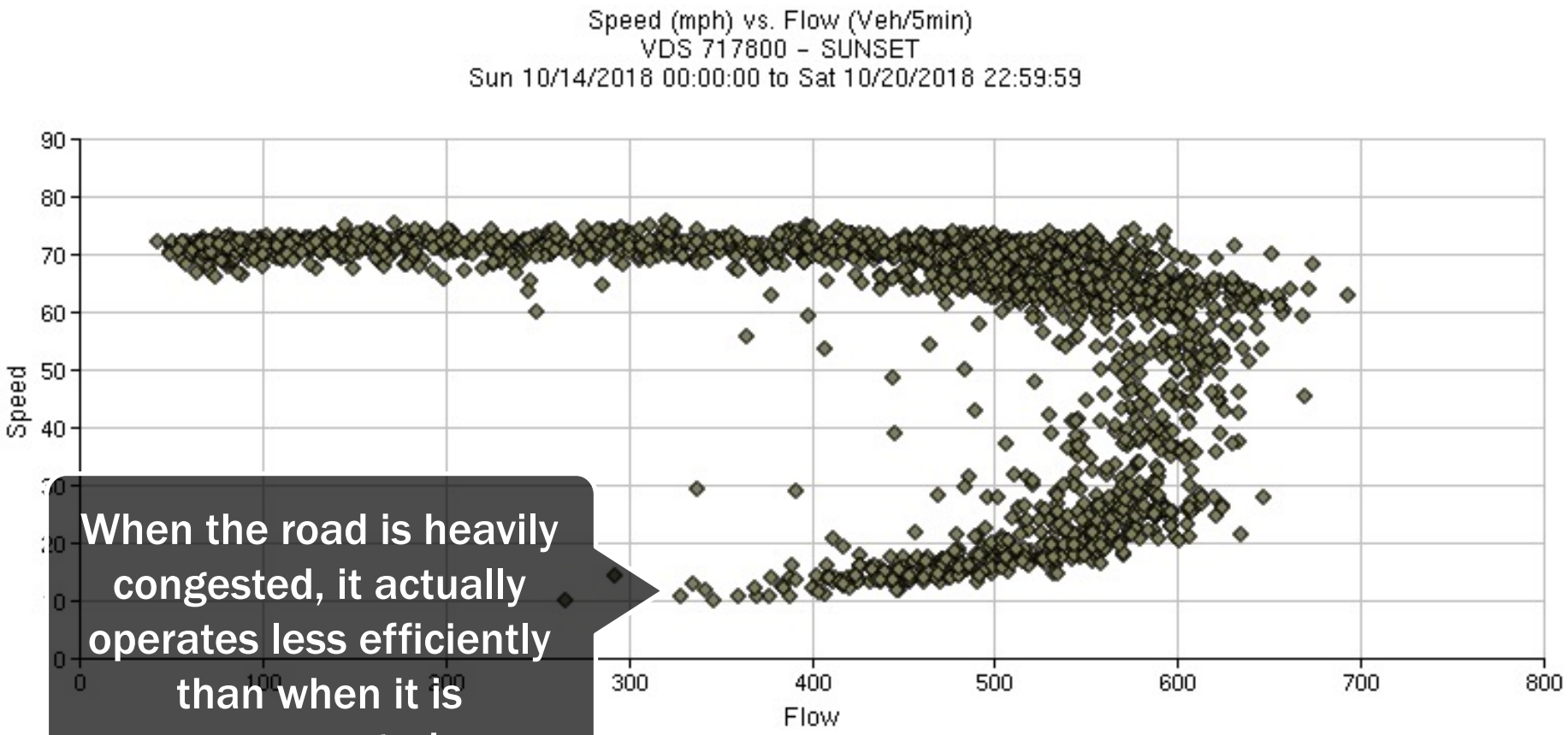
An Illustrative Example



By taking the freeway, a driver might save 5 minutes on his or her commute. At the same time, the resultant delay to other cars on the freeway could amount to hours.

Congestion is Inefficient



When the road is heavily congested, it actually operates less efficiently than when it is uncongested.

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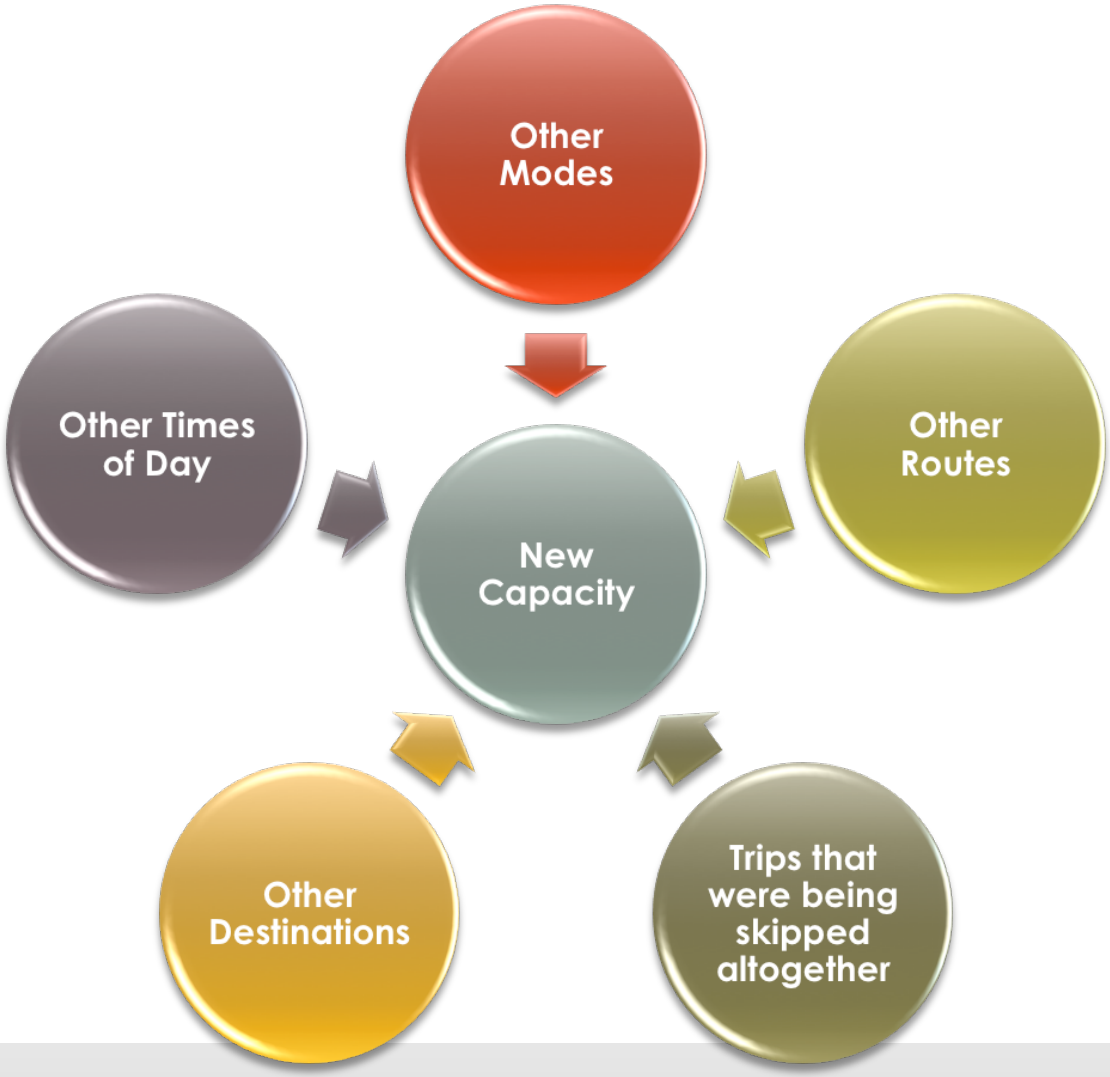
Capacity Expansion has Limits



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Problems with Congestion

- When travelers are delayed, they pay with time, and that time is lost to society. Nobody benefits.
- Having to plan for unreliable travel times is inefficient, too: arriving early isn't always useful/productive.
- It treats all trips equally, but not all trips are equal. A trip to the market is not as important as a trip to the emergency room.

Congestion on Strathmore Dr. after a UCLA Basketball game

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Simple Scenario to Consider

- Two commuter buses from suburbs to downtown.
- One departs at 8 AM, one departs at 9 AM.
- Each bus can carry 10 passengers.
- 20 customers need to get to downtown, and all 20 arrive at the bus pick-up point at 8 AM.

What do you do?

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Solving Congestion with Pricing

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How ExpressLanes Work

1. Use transponder to declare vehicle occupancy.
2. Enter/exit at designated access points.
3. Guide signs alert drivers of entrances ahead.
4. Message signs before each entrance display current prices.
5. Guide signs alert drivers of entrance opportunities.
6. White signs remind drivers that FasTrak is required for all vehicles in the lanes.

CARPOOLS AND VANPOOLS can use the ExpressLanes ***toll free*** with FasTrak Flex.®*

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Benefits of Congestion Pricing

- Efficient use of capacity.
- Provides option for faster travel.
- Revenues can be reinvested.
- HOVs, vanpools, motorcycles free.

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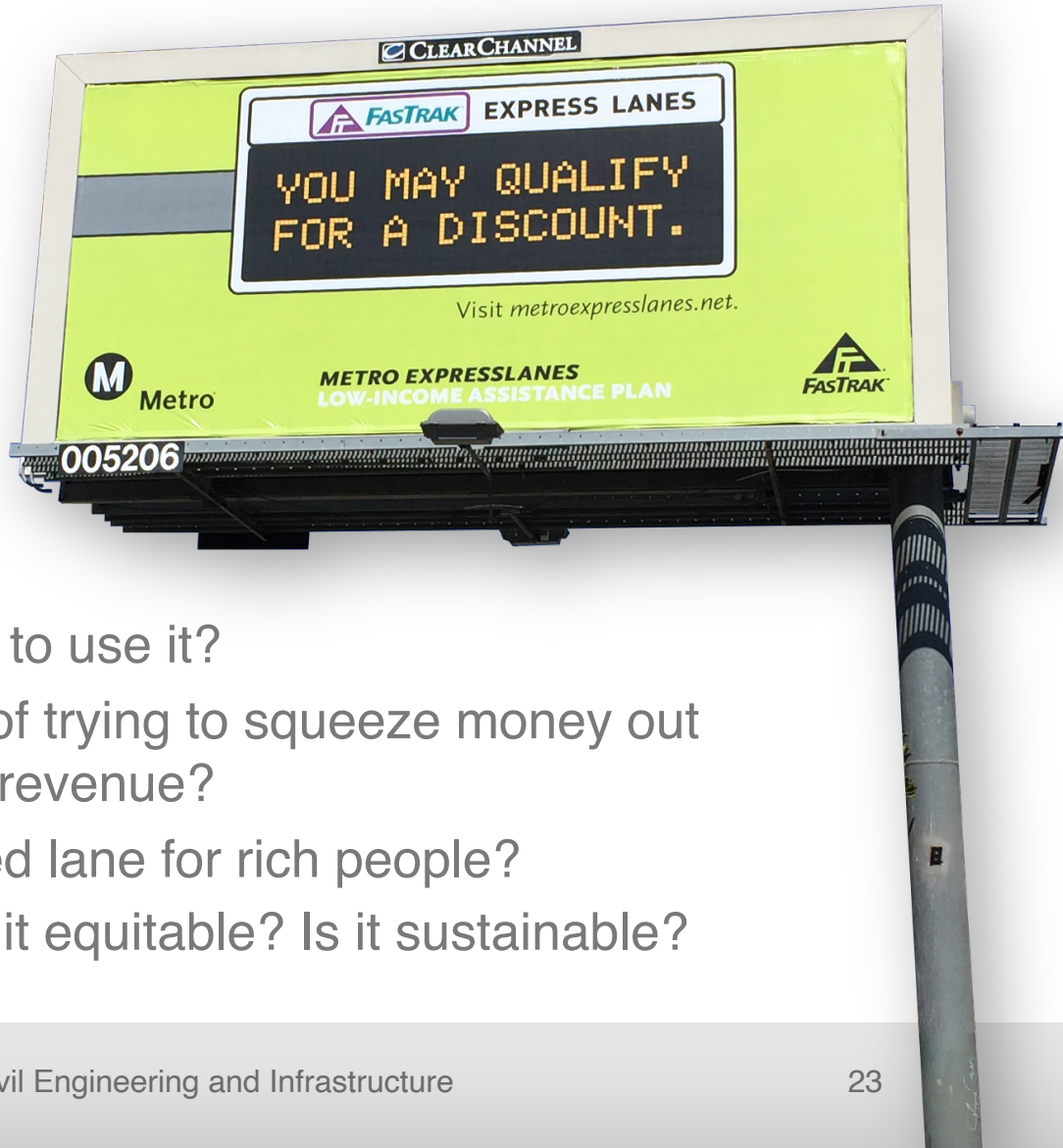
Common Questions & Concerns

- It's a "freeway," so shouldn't it be free by definition?
- Since our roads are provided by the government, shouldn't they be free for the public to use?
- The road is already built and paid for by gas taxes, so why should we pay again to use it?
- Isn't this just one more way of trying to squeeze money out of people, to generate more revenue?
- Isn't this basically a dedicated lane for rich people?
- Is congestion pricing fair? Is it equitable? Is it sustainable?



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Equity Concerns

"We have so normalized the current condition of our transportation system that we unthinkingly consider it fair and functional. It is neither. Our system is an embarrassment to efficiency and an affront to equity. The choice between fairness and efficiency, in this case, is a false one. Charging prices would increase efficiency. Dedicating some revenue to the poor would protect equity. Falling pollution might well advance equity. There is nothing intrinsically unfair about pricing roads, or intrinsically fair about leaving them free. And people who worry about harms to the poor when roads are priced, but not when roads are free, may be worried more about the prices than the poor."

— **Dr. Michael Manville**
Associate Professor of Urban Planning
UCLA Luskin School of Public Affairs

For More Information

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Learn More, Get Involved

- Transportation Courses:
  - **C&EE 180: Introduction to Transportation Engineering**
  - C&EE C181: Traffic Engineering Systems: Operations and Control
  - C&EE C182: Rigid and Flexible Pavements
  - C&EE C185: Transportation Systems Analysis
  - C&EE C186: Intelligent Transportation Systems
  - Urban Planning M120: Introduction to Cities and Planning
  - Urban Planning M150: Transportation Geography
  - Urban Planning CM151: Transportation and Land Use: Parking
- Get involved in organizations: ITE, ITSCA, WTS, ASCE.
- Internship, volunteer, and research opportunities.
- Consider graduate school to learn even more.

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Real World Research

- How effective are adaptive traffic signal networks?
- Why is there congestion at *[location]* and how can we fix it?
- What can we do to reduce crashes at *[location]?*

Topic Highlights

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C&EE 180 Themes

- Introduction. Transportation Safety. Planning Tools. Jurisdictions.
- **Road hierarchy and design. Cross-sectional elements.**
- **Vertical and Horizontal Curves. Superelevation.**
- Motor Vehicles. Pavement Design.
- Cost estimating and engineering economics.
- Traffic control devices. Intersection capacity.
- Freeway flow. Freeway bottleneck analysis.
- **Pricing for transportation users.**
- **Transportation economics (supply and demand).**
- Off-Street Parking.
- Bikeways, E-Scooters, Pedestrian Facilities and the ADA.
- Environmental Studies.
- Marine Transportation.
- Public Transit Buses.
- Railroad Engineering.
- Goods Movement.
- Air Transportation.
- Urban Rail Transit.

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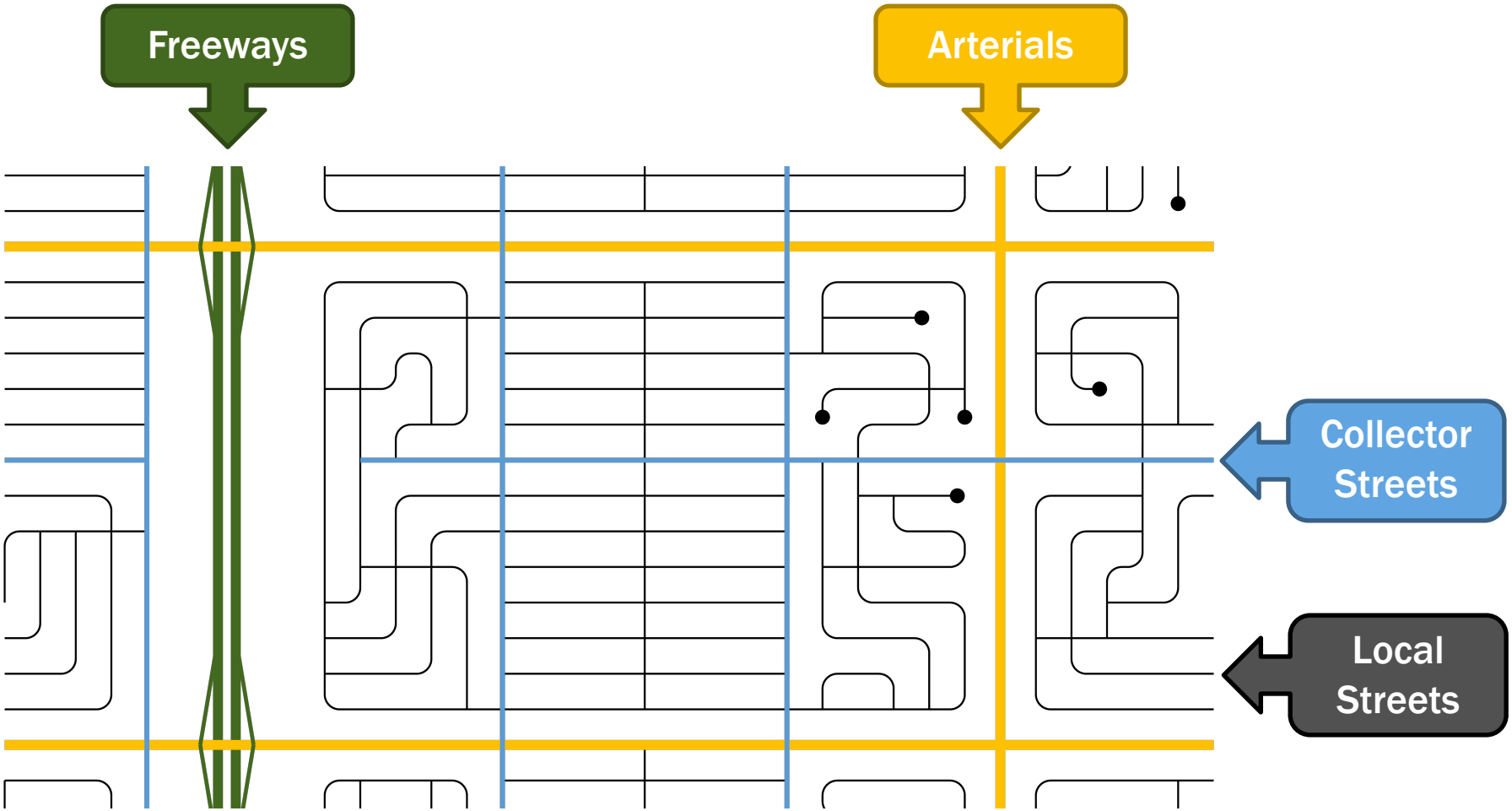
Road Hierarchy Preview



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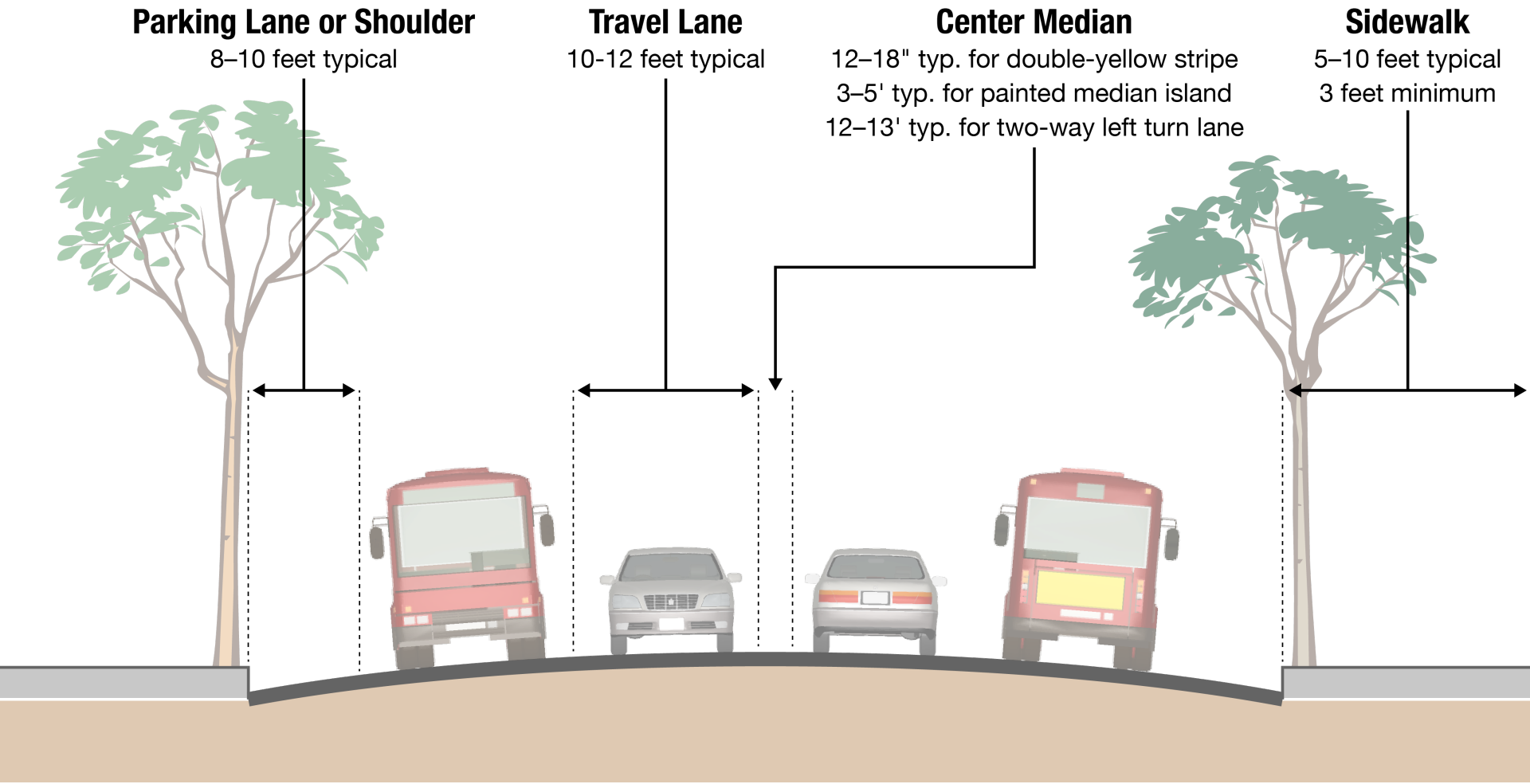
Cross-Sectional Elements Preview



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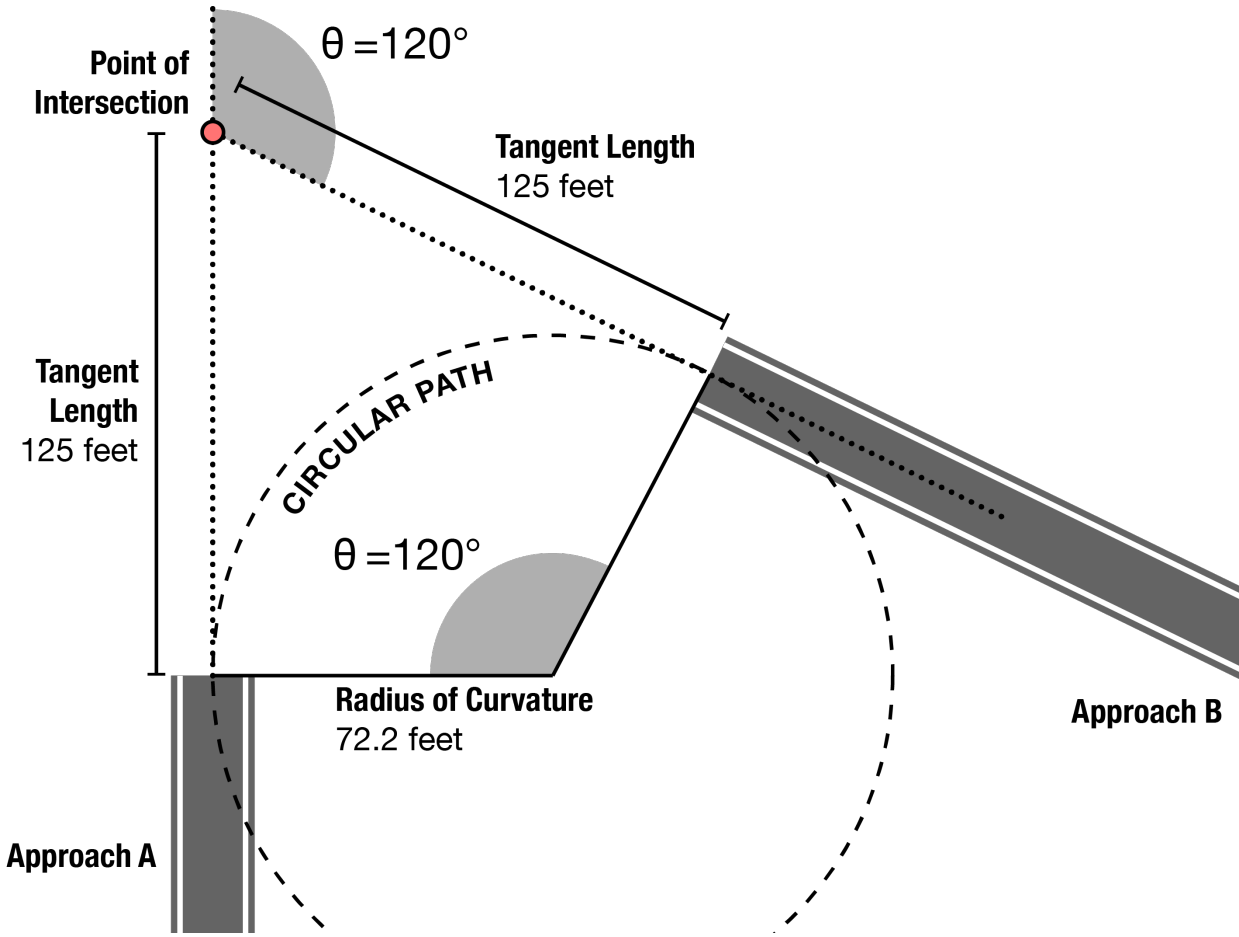
Horizontal Curves Preview

Given a Tangent Length of 125 feet and an Angle of Deflection of 120°, use the Tangent Length equation and solve for R:

$$T = R \tan\frac{\theta}{2}$$

$$125\ ft = R \tan\frac{120°}{2}$$

$$72.17\ ft = R$$



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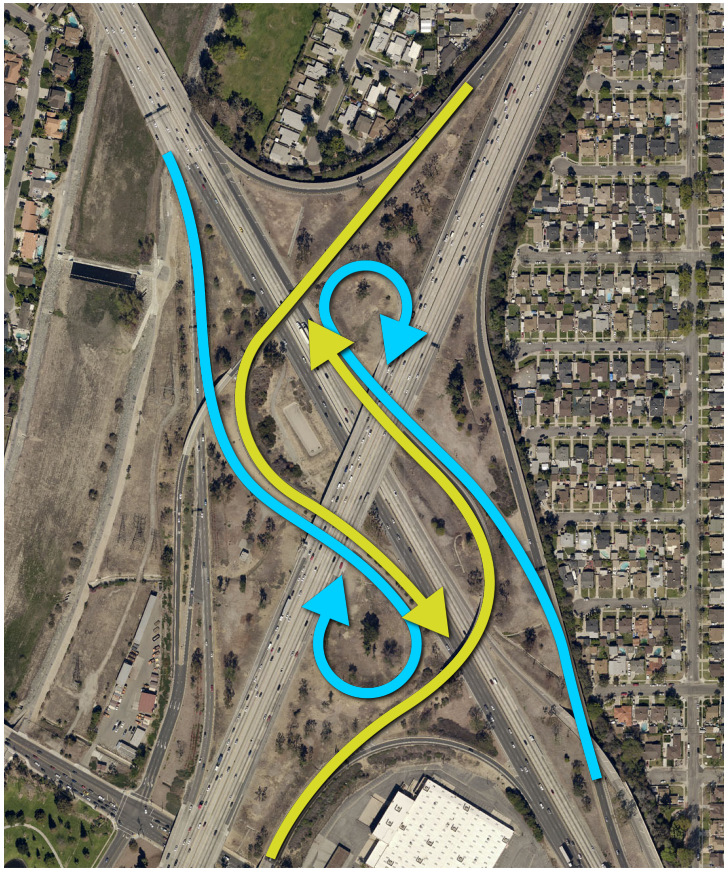
Horizontal Curves Preview

- The higher-volume green movements are designed with relatively wide curves that have higher design speeds: 30 mph in this case. These ramps require one overpass each, which significantly increases cost.
- The lower-volume cyan movements are designed with tighter curves that have lower resultant design speeds (20 mph in this case). These ramps require no overpasses and are therefore less expensive to build.



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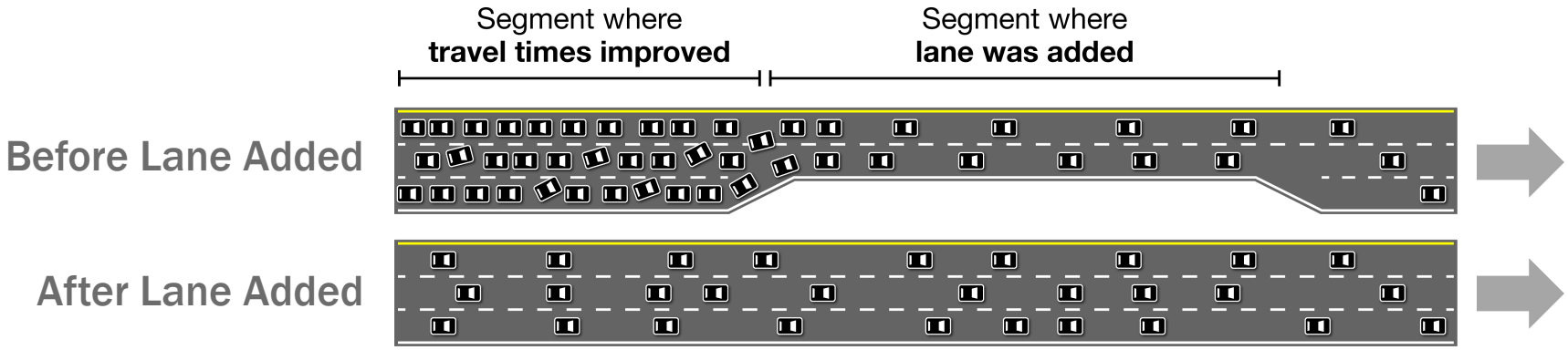
Transportation Economics Preview

- A 2014 study showed that travel times barely improved after the new HOV lane opened on I-405 in the Sepulveda Pass.
- Some shortfalls of focusing on travel times to evaluate the project:
  - The travel times were measured on the segment with the new lane, when in fact the more appropriate segment to study would have been ***upstream*** of the improvement (see below)
  - Focusing on freeway travel times misses the fact that more people are now being served by the freeway (see next slide)
  - Focusing on freeway travel times misses any benefits to adjacent arterials.
  - Without a control group, there is no way to know whether things would have been even worse without the new lane (e.g., congestion getting worse region-wide)



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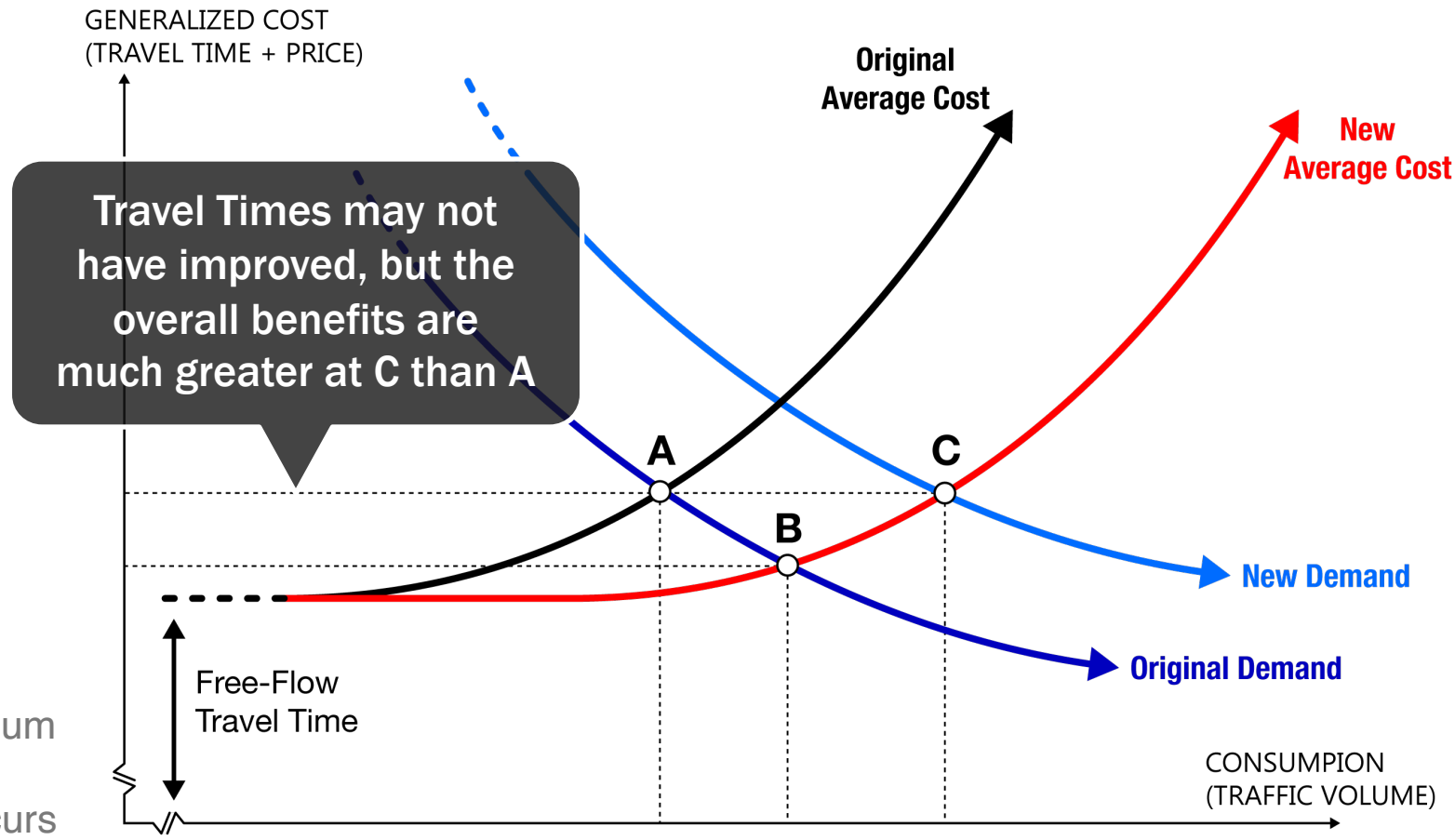
Transportation Economics Preview

A:
Original Equilibrium

B:
Initial New Equilibrium

C:
New Equilibrium after Induced Demand Occurs



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C&EE 181 Themes

- Basic Concepts. Traffic Safety. Agencies and Jurisdictions.
- Sight Distance. Intersection Control and Warrants.
- **Traffic Control Devices: Signs, Markings, Signals.**
- Collision Analysis.
- Roadway Striping and Speeds.
- Traffic Counts. Volume Studies. Design Tools.
- Signal Design and Phasing.
- Intersection Capacity and VMT.
- **Transportation Planning and Modeling.**
- **Traffic Flow Theory and Time-Space Diagrams.**
- Signal Timing Intervals, Coordination, Preemption, Priority.
- **Pedestrians, Bicyclists, Street Parking.**
- Queueing Analysis and Diagrams.
- **Autonomous/Connected Vehicles. Active Traffic/Demand Management.**
- Access Control to Private Property. Parking Design and Management.
- Roundabouts.
- Other Topics in Traffic Engineering.

Signage Color Meanings

- The MUTCD defines sign background colors in §1A.12.

Black or White:
Regulation

Green:
Direction, Guidance

Blue:
Motorist Services

Orange:
Temporary/Work Zone

Brown:
Recreation, Cultural

Purple:
Electronic Toll Lanes

Fluorescent Pink:
Incident Management

Red:
Rule or Prohibition

Fluorescent Yellow/Green:
Ped, Bicycle, School, Playground Warnings

Yellow:
Warning

Regulation vs. Warning

- A sign's color indicates the difference between something that's punishable and something that's just advice.

W13-3

R2-1

The yellow sign above is a speed advisory, warning drivers to slow down (e.g., for a ramp or a curve). The white sign is a regulation or rule, which you can be ticketed for violating.

This yellow warning sign (deprecated) appears first, to warn drivers that the right lane will exit. The white regulatory sign is next, telling drivers that they are committed to exiting at that point (MUTCD §2B.23)

Liability Example

MUTCD §4D.09: The relative positions of signal sections in a vertically-arranged signal face, from top to bottom, shall be as follows:

- CIRCULAR RED
- Steady and/or flashing left-turn RED ARROW
- Steady and/or flashing right-turn RED ARROW
- CIRCULAR YELLOW
- CIRCULAR GREEN
- Straight-through GREEN ARROW
- Steady left-turn YELLOW ARROW
- Flashing left-turn YELLOW ARROW
- Left-turn GREEN ARROW
- Steady right-turn YELLOW ARROW
- Flashing right-turn YELLOW ARROW
- Right-turn GREEN ARROW

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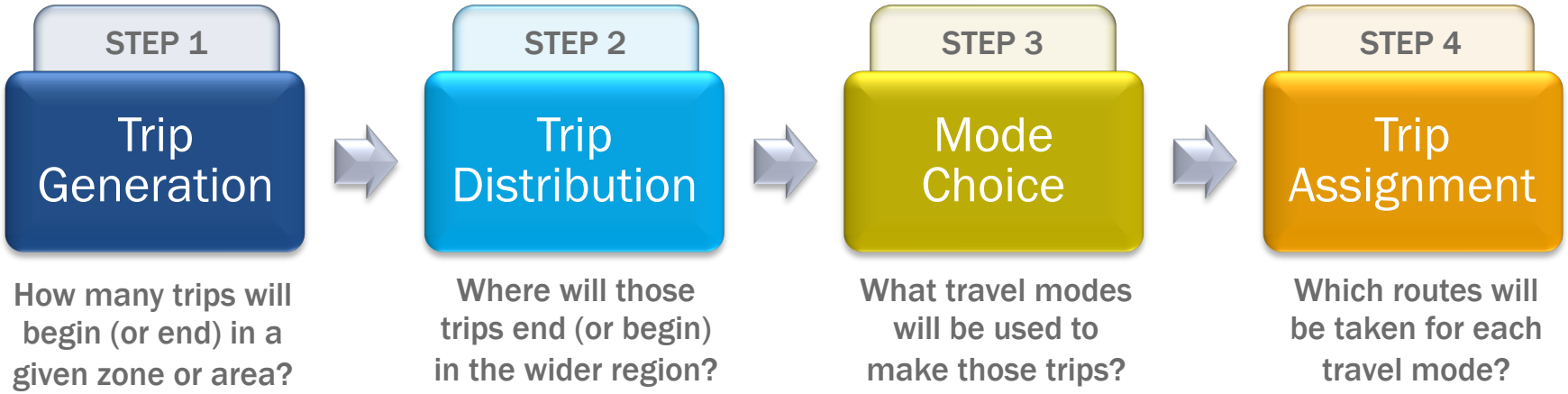
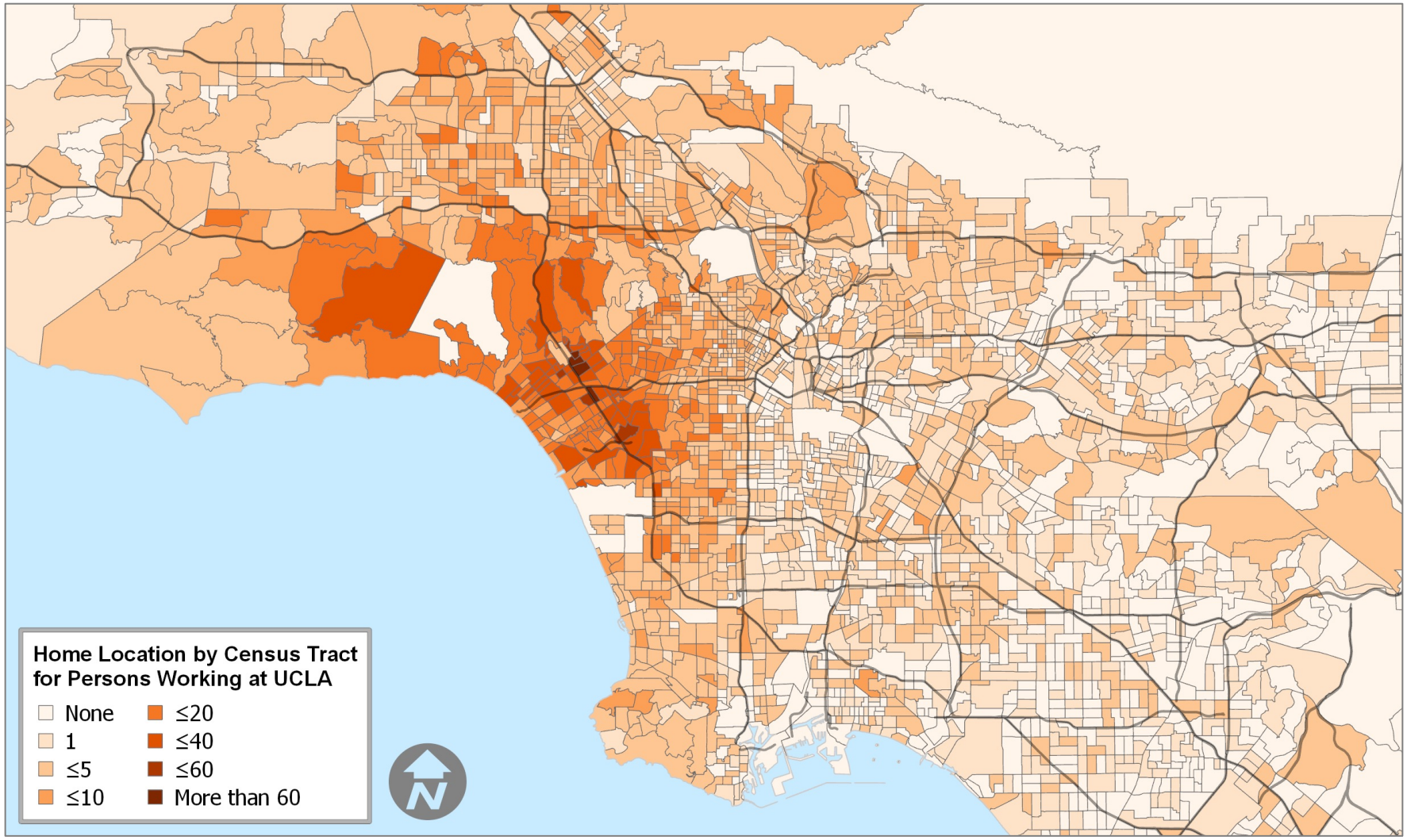
Planning: The Four-Step Model

- Traditional approach to estimating the number of trips that will occur in a given area. Includes evaluation of:
  - **Trip Generation and Distribution:** Where the trips will begin and end
  - **Mode Choice:** What travel mode the trips will use
  - **Trip Assignment:** What routes the trips will take





Origins for Work Trips to UCLA Campus

Based on 2017 US Census Survey Data. Sample Size of 10,482.

Data Source: Longitudinal Employer-Household Dynamics (LEHD) Origin-Destination Employment Statistics (LODES) data.

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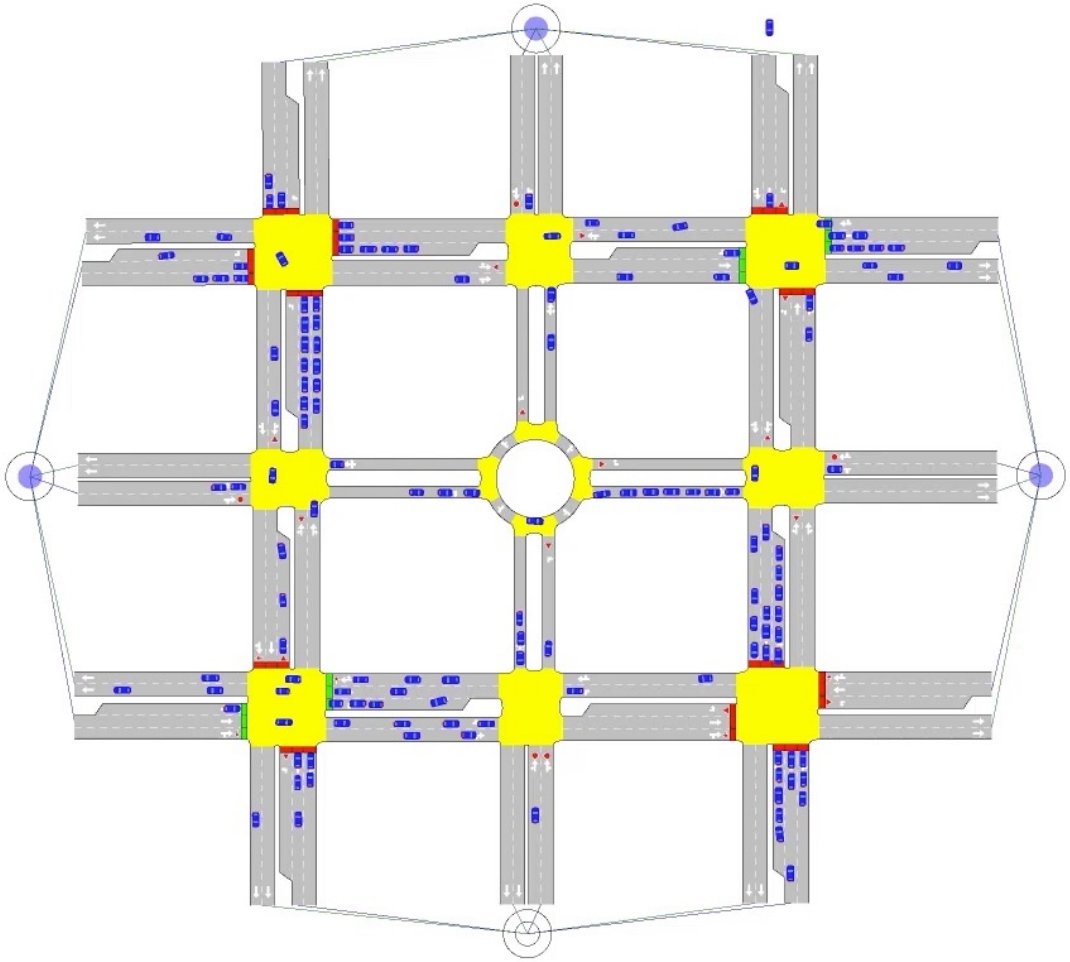
Simulating Complex Routing

- This relatively simple network of four origins, four destinations, and nine intersections contains dozens of potential routes between any given O-D pair.
- Factor in the dynamic nature of conditions on the network over time as well, and the trip assignment exercise quickly becomes impractical to perform manually.



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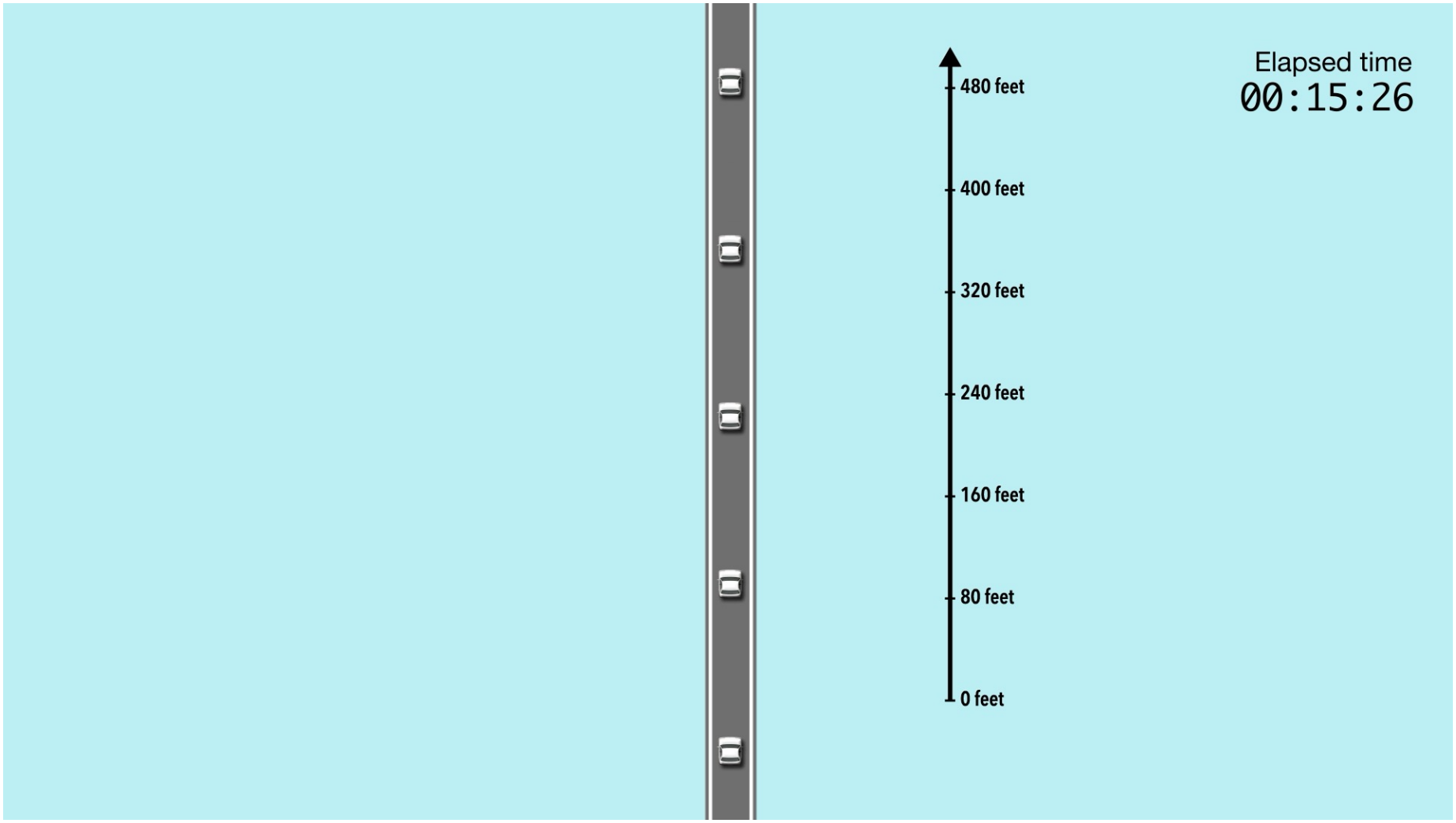
Traffic Flow Theory: Parameters



Curb Colors

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Summary of General Curb Color Meanings, for City of Los Angeles

Color	Meaning
Red	No stopping. Enforced 24/7.
Yellow	Commercial loading only. Vehicles with commercial plates can park for up to 30 minutes when loading. Vehicles without commercial plates can still use for passenger loading, for up to 5 minutes. Enforced 7 AM to 6 PM, Monday through Saturday, unless otherwise posted.
White	Passenger loading only, for up to 5 minutes. Enforced 24/7.
Green	Time-limited parking (see signs). Enforced 8 AM to 6 PM, Monday through Saturday, unless otherwise posted.
Blue	Reserved for drivers or passengers that have been assigned a disabled parking placard or license plate.

DATA SOURCE: https://ladot.lacity.org/residents/colored-curb-zones

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Active Management: Barriers

SOURCE: *Lindsay Transportation Solutions. Video URL: https://www.youtube.com/watch?v=ljJjqp48Cqo (used with permission)*

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Integrated Corridor Management

- **Integrated Corridor Management** is defined by FHWA as "the coordination of individual network operations between adjacent facilities that creates an interconnected system capable of cross-network travel management."
- Enables more efficient operation of a corridor under a range of operational conditions & scenarios.
- May include integration of:
  - Transit Systems
  - Freeway Operations
  - Arterial Operations
  - Parking Systems
  - Traveler Information Systems
  - Incident Response Systems

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Automated & Autonomous Vehicles

Automated Vehicles use onboard sensors/equipment to drive in partially-automated or fully-automated modes. They are self-contained “islands.” When all aspects of driving are fully automated, the vehicle is an **autonomous vehicle (AV).**

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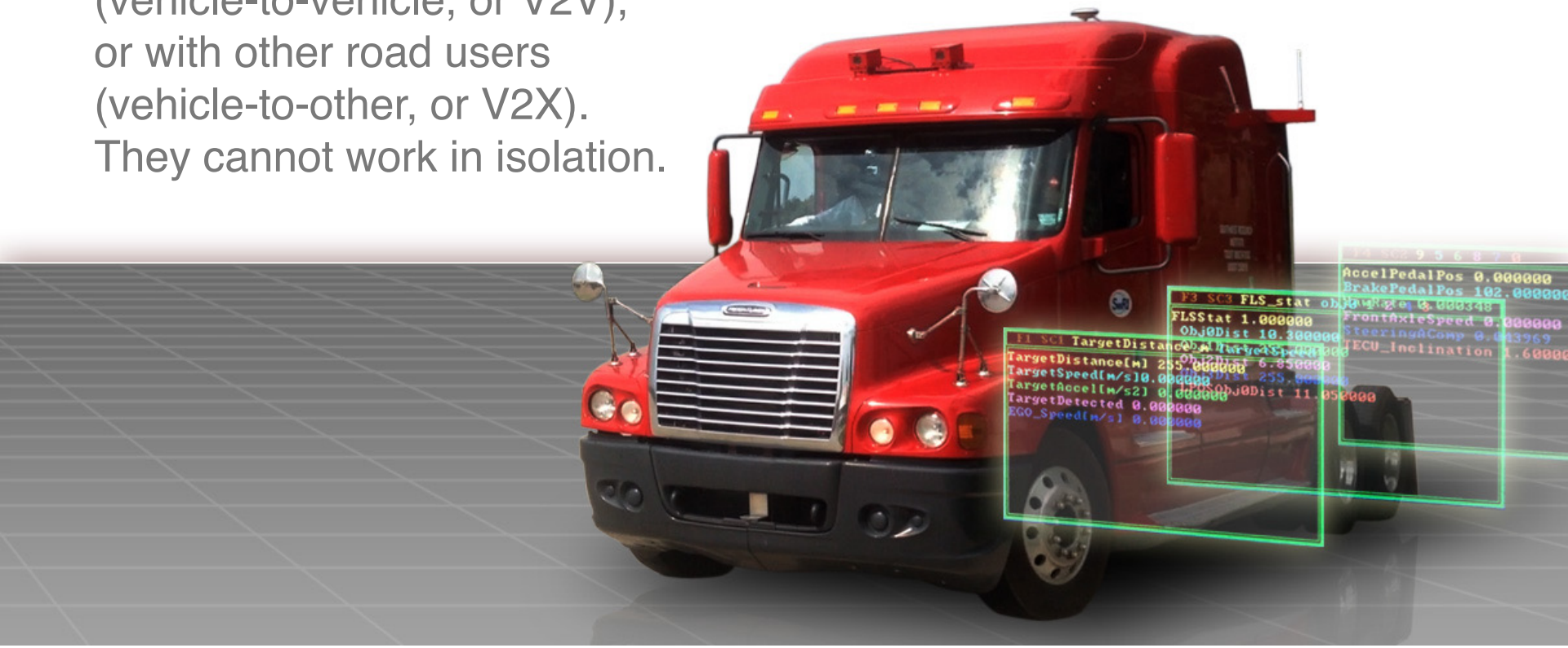
Connected Vehicles

Connected Vehicles (CVs) communicate in real time with infrastructure (vehicle-to-infrastructure, or V2I), with each other (vehicle-to-vehicle, or V2V), or with other road users (vehicle-to-other, or V2X). They cannot work in isolation.



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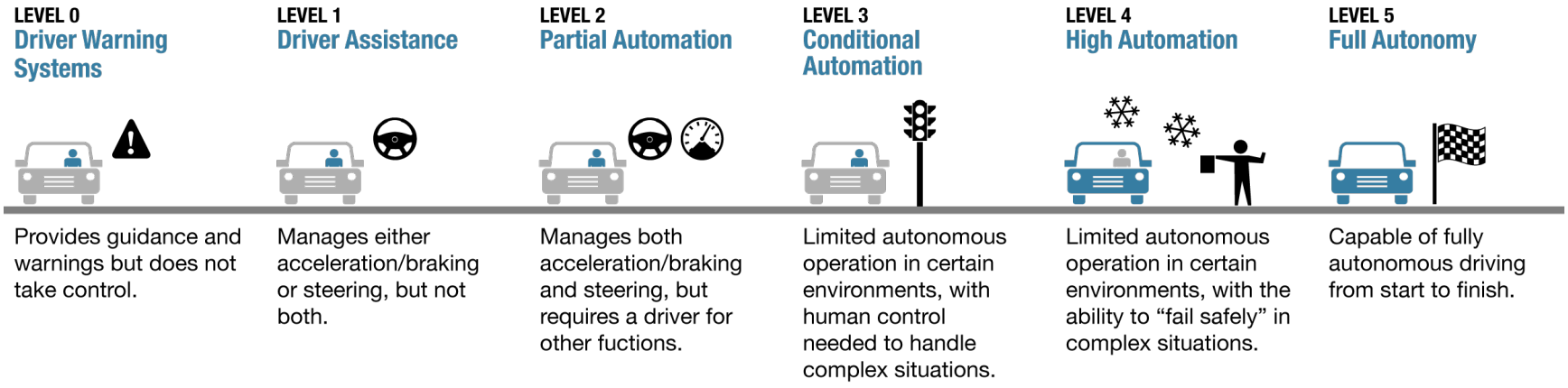
Levels of Automation

- Level 3 automation has proven particularly elusive for commercial vehicle manufacturers.
  - For example: Audi A8 and Tesla Autopilot have targeted Level 3 but not attained it.
- Level 3 automation comes with liability challenges, since the human driver and automated system share responsibility.
  - Drivers may fail to properly pay attention when Level 3 automation is engaged.
  - Manufacturers are considering skipping to Level 4 automation instead.
- A truly **autonomous** vehicle would exist only at **Level 5.**



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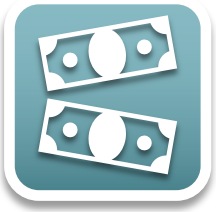
AV Research Needs

How should the transition be done?



Who will be responsible in a crash?

How should the car handle errors?

What does this mean for [industry]?

Will people stop owning cars?

How will fully autonomous fleets impact road design?

What should the car's priorities be?

Will congestion and VMT increase or decrease?